Hardmast Production in the Missouri Ozarks:
a preliminary report of acorn production on MOFEP sites

Carrie Steen, Randy Jensen – Forest Systems Field Station
Larry Vangilder, Steve Sheriff – Resource Science Center
Resource Science Division, Missouri Department of Conservation

Introduction

People have long been interested in the production of hardmast, primarily acorns. According to Christisen and Kearby (1984), the first formal measurement of acorn production in Missouri began with the U.S. Forest Service in 1939 by personnel concerned with oak regeneration. Since that time, there have been numerous studies in Missouri and elsewhere concerning acorn production both from the standpoint of reproduction and wildlife forage.

When this study began in 1993, the intent was to address growing concerns that the public's opposition to clear-cutting (even-aged management or EAM) was resulting in decreased wildlife habitat and food sources. This practice creates early-successional habitat in harvested stands conducive to diverse ground cover and berry-producing vegetation. However, it also requires removal of most overstory trees, the very trees mature enough to produce hardmast. The alternative, uneven-aged management (UAM), leaves more mature mast-producing trees in harvested stands, but was thought to not allow enough canopy openings at the compartment level to provide adequate early successional habitat. In either of these cases, there was the realization that hardmast plays an extremely important role in the characteristic oak-hickory forests of Missouri and that each type of management may have different impacts on hardmast production.

Through previous studies (Beck 1977; Goodrum, et al. 1971) and anecdotal evidence, hardmast production was known to be highly variable from year to year. In order to gain information on both management affects and natural temporal fluctuations, this study was developed based on the MOFEP experimental design. This allows us to examine forest management affects as well as unmanaged mast production. The purpose of this study is to collect mast each year in EAM, UAM and No Management (NM) sites to determine inherent variability and long-term impacts of harvest on mast production. There are currently more detailed analyses in progress, so the intent of this report is to provide an update of some general trends that have been noted now that some time has passed since the first harvest on MOFEP sites.

Methods

Study Site and Plot Placement

Stratified random sampling was used to determine plot placement. Each of the nine MOFEP sites was divided spatially into four ELT groupings. Half-acre plots were randomly placed in each ELT group proportional to the area of ELT groups in each site. This resulted in 130 plots total: 23 on ridgetop ELTs, 45 on south and west slope ELTs, 40 on north and east slope ELTs, and 22 in a group of all other ELTs comprised primarily of upland waterways.

Mast Collection

Each plot contains 20 wire mesh cone traps arranged in a 4 X 5 grid (Figure 1). Each trap is 0.73m in diameter so that a total area of 8.4 m^2 is sampled in each plot. This allows estimation of hardmast production per area, rather than by individual trees.

All hardmast is removed from cones every 2-4 weeks from early August through early January. This is collected in paper bags and allowed to air dry for the duration of mast fall. After all mast is collected, each plot is processed by separating mast by species. Hickory nuts and walnuts are included but the focus of this paper is acorns. Once acorns are separated by species, they are separated into maturity classes, following guidelines by Christensen and Kearby (1984). Each maturity class is then further separated by the presence of animal damage. At this point, total count and weight are recorded by each damage group for immature acorns. Mature and nearly mature acorns follow the same procedure initially. Those with no animal damage are then sub-sampled and cut open to determine if they are sound and capable of germinating, or have other evidence of internal damage. This damage is recorded as insect damage (weevils) or other (fungus, mold, abnormalities, etc,). All results presented here are based on sound acorns.

Results

Average number of mature, sound acorns per plot was calculated for annual production, treatment, ELT and species group (red and white oak). No mast was collected in 1996 during harvest activities, and 2003-2004 were not used due to changes in how the mast was processed.

General Trends

Regardless of treatment, acorn collection on MOFEP sites shows the great amount of annual variability that seems inherent when considering acorn production in a relatively short time period (Fig. 2). These wide fluctuations can be seen in each of the oak subgroups (Fig. 3), even though red oak acorns take two years to reach maturity, while white oak acorns only take one year. Interestingly, even with different seeding phenologies, red and white oak production generally follows the same direction of fluctuation. Red and white oak production either both increased or both decreased in six of nine year-to-year comparisons (67% - Table 1). In 8 of 12 collection seasons, there is a greater number of red oak acorns collected in a year than white oak acorns. This is most likely explained by the overstory composition. Both prior to and after the first MOFEP harvest, red oak species accounted for 66% of oak trees at least 8” DBH in the hardmast collection plots (Table 2). There is also a disparity in the subgroups in how frequently a “bust” (< 20 acorns/plot) year occurs (Table 3).   In 12 seasons there were 7 white oak busts and 4 red oak busts, primarily after harvest. In only 2 years the subgroups synchronized to cause a total acorn bust. This would suggest that red oak acorn crops are more likely to produce continued forage for many mast dependant species and minimize the potential for dramatic population fluctuations. However, this could also be another effect of the overstory composition. Since white oak accounts for only one-third of the >8” oak trees so that the number of white oak acorns tends to be less than red oak, there could simply be a greater chance that the white oak acorns/plot count will drop below 20.

When considering production by species (Fig. 4), species specific variability begins to emerge. For the white oak sub-group, the two primary species are white oak (*Q. alba*) and post oak (*Q. stellata*). Figure 4 indicates that both species generally track the same fluctuations as overall production. White oak tends to produce more than post oak, which is not surprising since white oak comprises 73% of that subgroup’s overstory trees. Even so, post oak production surpassed white oak in 1999, and in two time periods showed increased production from the previous year while white oak decreased (1997-1998, 2005-2006). This may at first indicate that post oak acorns may provide a good portion of the subgroup’s forage potential and may in some years even compensate for reduction in white oak acorns. However, since post oak acorns are much smaller than white, analyses using biomass rather than counts will be needed.

For the red oak subgroup, 50% of the overstory is in black oak (*Q. velutina*) and 46% in scarlet oak (*Q. coccinia*). But these two species do not seem to share the same fluctuations with each other as closely as white and post oak. As evident in Figure 4, this time period shows scarlet oak tending to spike more frequently and to a greater extent than other species. In years with poor overall production, the other species at least produced some acorns, albeit very little, while scarlet oak was more likely to not produce any mature acorns. In contrast, black oak production certainly varies but did not exhibit such a sharp "boom and bust" pattern as scarlet oak. Black oak also appears to have a more cyclical pattern where there is a relatively large increase in production followed by 3-4 years of gradual decline ending in a bust, with another increase the next year. It is difficult to determine if this is a true cycle at this point though.

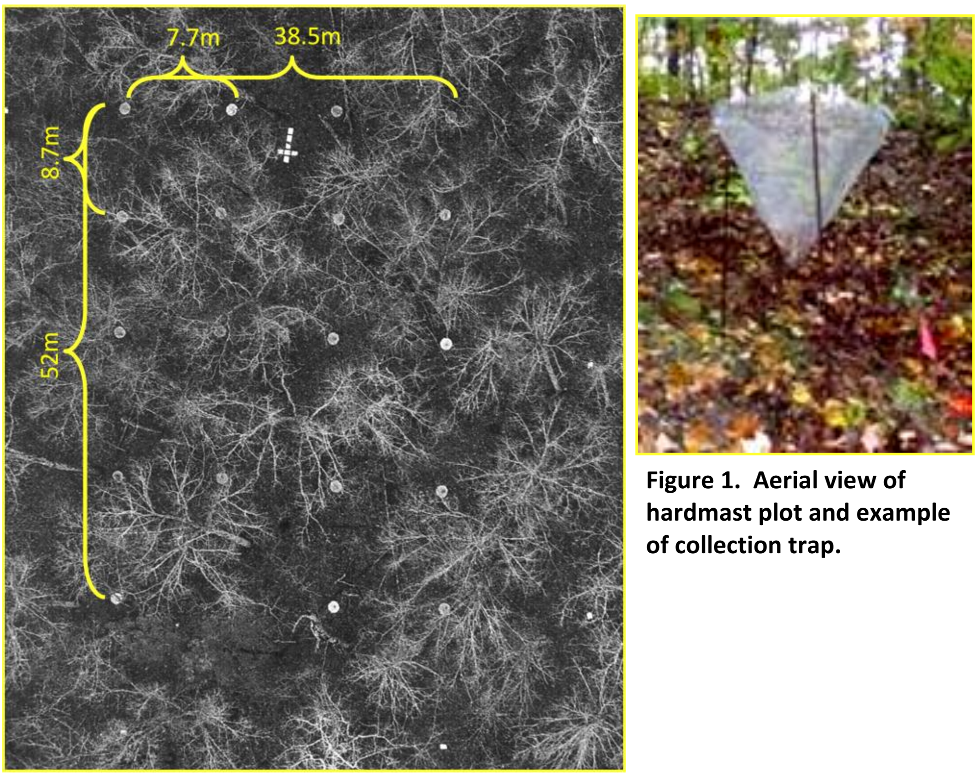


Figure 1. Aerial view of hardmast plot and example of collection trap.

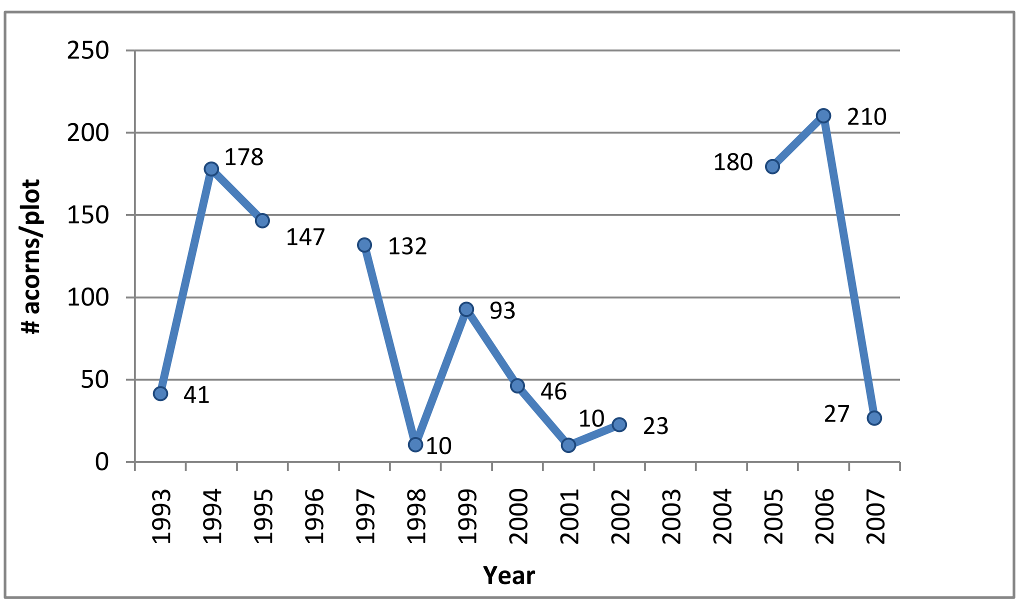


Figure 2. Average number of sound, mature acorns per half-acre plot (n=130), all species.

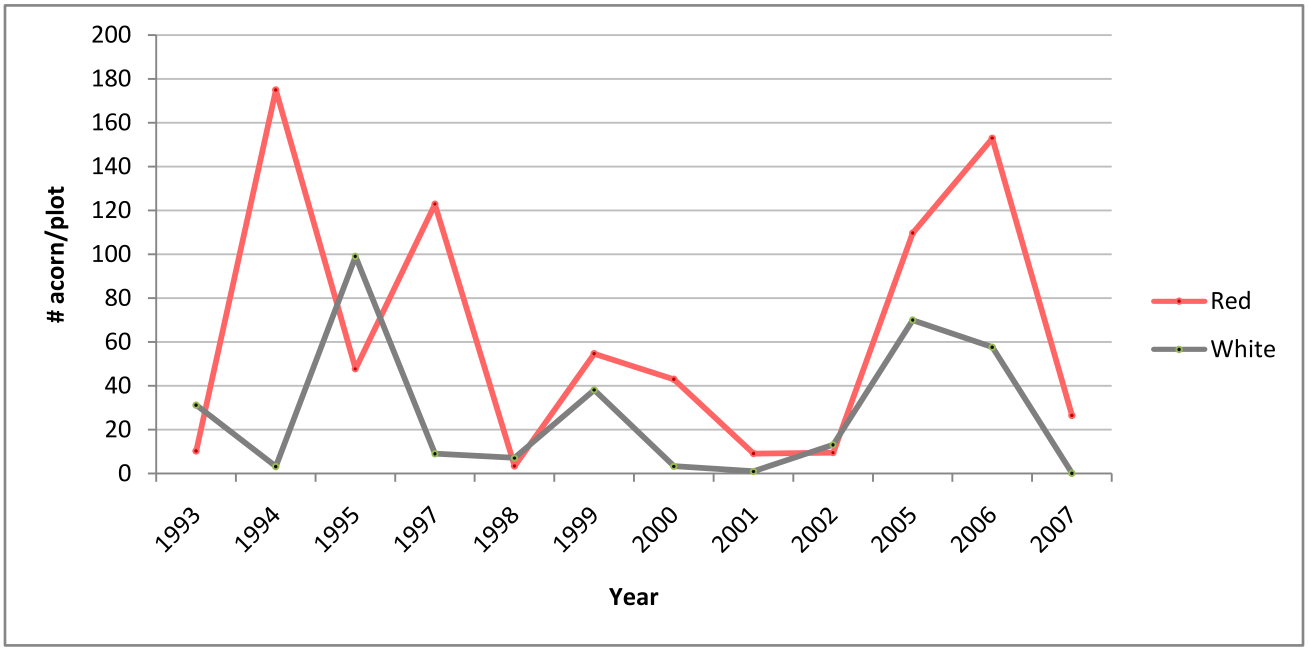


Figure 3. Average number of acorns collected per plot (n=130) by oak sub-group.

Table 1. Total number of acorns collected, direction of change from year to following year (increase or decrease) and whether subgroup fluctuations occurred in the same or opposite direction.

	Red		White		
1993	1343		4050		
1994	22731	Inc	414	Dec	opposite
1995	6202	Dec	12867	Inc	opposite
1996	no data				
1997	15968		1171		
1998	444	Dec	916	Dec	same
1999	7104	Inc	4949	Inc	same
2000	5587	Dec	425	Dec	same
2001	1186	Dec	120	Dec	same
2002	1232	Inc	1708	Inc	same
2003	no data				
2004	no data				
2005	14247		9091		
2006	19875	Inc	7487	Dec	opposite
2007	3448	Dec	12	Dec	same

Table 2. Percent of trees > 8" DBH in MOFEP Hardmast plots.

	1995			1998		
	# Trees	% Total	% Subgroup	# Trees	% Total	% Subgroup
Black	1329	33	50	1236	34	51
Scarlet	1216	30	46	1089	30	45
N. Red	72	2	3	85	2	4
Other	31	1	1	18	0	1
White	991	25	73	947	26	75
Post	348	9	25	287	8	23
Chinkapin	26	1	2	24	1	2
Total Red	2648	66		2428	66	
Total White	1365	34		1258	34	
Total	**4013**	**100**		**3686**	**100**	

Table 3. Acorns per plot, total and subgroups. Grayed cells indicate bust years.

	Total	Red	White
1993	41	10	31
1994	178	175	3
1995	147	48	99
1996			
1997	132	123	9
1998	10	3	7
1999	93	55	38
2000	46	43	3
2001	10	9	1
2002	23	9	13
2003			
2004			
2005	180	110	70
2006	210	153	58
2007	27	27	0

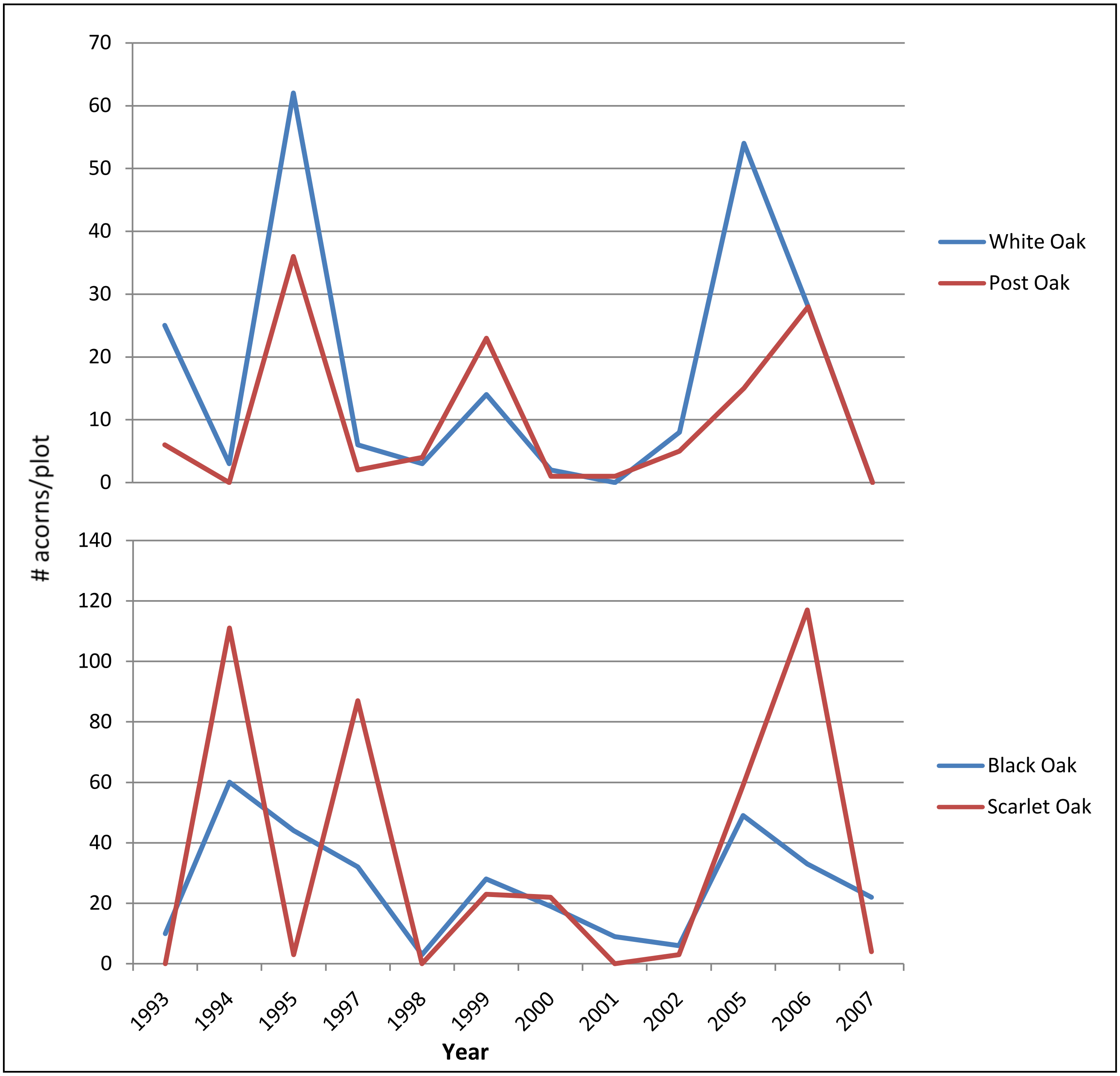


Figure 4. Number of acorns/plot (n=130) collected from primary oak species. Note different scale on Y-axes.

ELT

In most years, either northeast slopes or ridge tops tended to produce the greatest number of mature acorns per plots, while other ELTs (mostly upland waterways) usually produced the least (Fig. 5). A preliminary look at subgroup production by ELT can be found in Fig. 6. Plots in the upland waterways ELT, while nearly always lower than other ELT groups, seem more likely to produce more white than red oak acorns. This is reversed from the other ELTs where red oak usually produces more acorns than white oak. However, the fluctuation patterns generally mimic each other between the ELTs and the oak subgroups.

Treatment

Since the main objective of this study is to determine how harvest affects mast production and the variability in production, the plots were also grouped by management type. It may take a greater portion of a full rotation to really distinguish management affects from natural variability, but there are some interesting notes at this time. Again, overall production trends experienced similar fluctuations among harvest applications, but a noticeable change occurred from 1995-1997 (Fig. 7). It is not surprising that EAM sites showed a reduction in acorn production from 1995 to 1997 following the 1996 harvest. But UAM sites maintained the same level of production in 1995 and 1997, as did NM sites. After the poor crop in 1998, EAM and UAM sites typically produced the same amount. In most years post-harvest when there were less than 50 acorns per plot, all management types had almost equal amounts of production. The exceptions are those years when there were better crops (1999, 2005, 2006) and the NM sites increased production to a greater extent than either of the harvested treatments.

When separating the subgroups within management applications (Fig. 8), more patterns begin to appear. Again it is no surprise that production by subgroup has generally been greater on the NM sites than either of the harvested sites. For the red oak group, production has been higher on NM sites in every year except one (2002), even if only by a few acorns per plot. The white oak group seems to show a different dynamic, primarily in the poorest production years. When overall production was less than approximately 50 acorns per plot, white oak production in the NM treatment was equal to or less than either of the other harvested treatments (Table 4). This could possibly suggest that harvest practices may somewhat moderate fluctuations in white oak production, but not necessarily red oak.

Another difference between the subgroups arises when looking only at the two active harvest treatments. Red oak production is generally greater on UAM sites than on EAM sites, while white oak production tends to be greater on EAM than UAM. It is not possible to determine the cause at this time due to several confounding factors. First, because of the extreme natural variability this is a fairly short time period from which to draw any truly accurate conclusion, even on NM sites. Second, there are inherent site differences as well as ELT differences as suggested by Vangilder (1997) that could be influencing production or interacting with management to a greater degree than known at this time. Third, because there has only been the first harvest entry of a full rotation, not all plots have had operational overstory manipulations yet. For example, there are several plots in the EAM sites that have had no overstory removal and at the plot level are essentially no different statistically than a plot in a NM site. So at this point, data from these plots are likely mitigating data from plots that have been harvested when analyzing data at a compartment or treatment level. However, even these initial general patterns can give us insight into directing future analyses.

Literature Cited

Beck, D.E. 1977. Twelve-year acorn yield in southern Appalachian oaks. Res. Note SE-244. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station. 8 pp.

Christisen, D.M. and W.H. Kearby. 1984 Mast measurement and production in Missouri (with special reference to acorns). Terrestrial Series #13. Missouri Department of Conservation. Jefferson City, MO. 34 pp.

Goodrum, P.D., V.H. Reid and C. E. Boyd. 1971. Acorn yields, characteristics, and management criteria of oaks for wildlife. J. Wildlife Management 35(3):520-532.

Vangilder, L.D. 1997. Acorn Production on the Missouri Ozark Forest Ecosystem Project Study Sites: Pre-treatment data. pp. 198-209 In Brookshire, B. L. and S. R. Shifley, eds. 1997. Proceedings of the Missouri Ozark Forest Ecosystem Project Symposium: an experimental approach to landscape research. 1997 June 3-5, St. Louis, MO. Gen. Tech. Rep. NC-193. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station,. 378 pp.

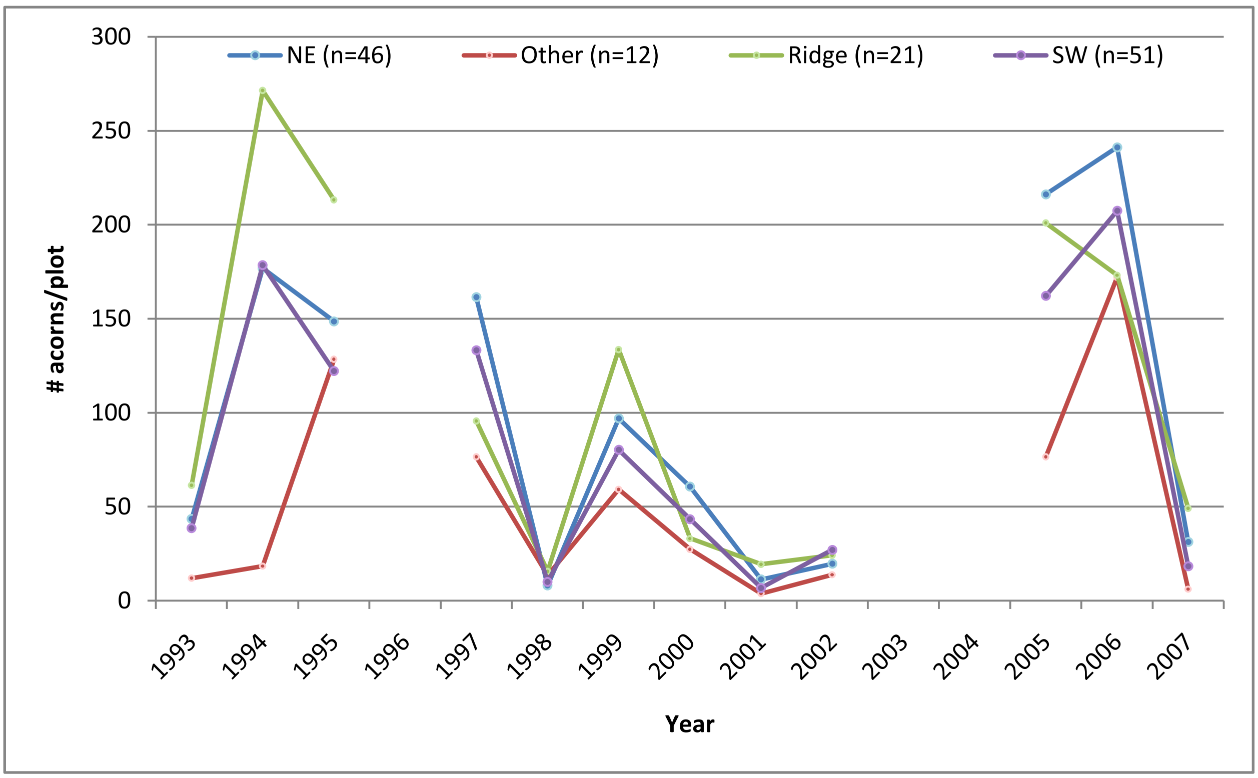


Figure 5. Average acorns per plot by ELT.

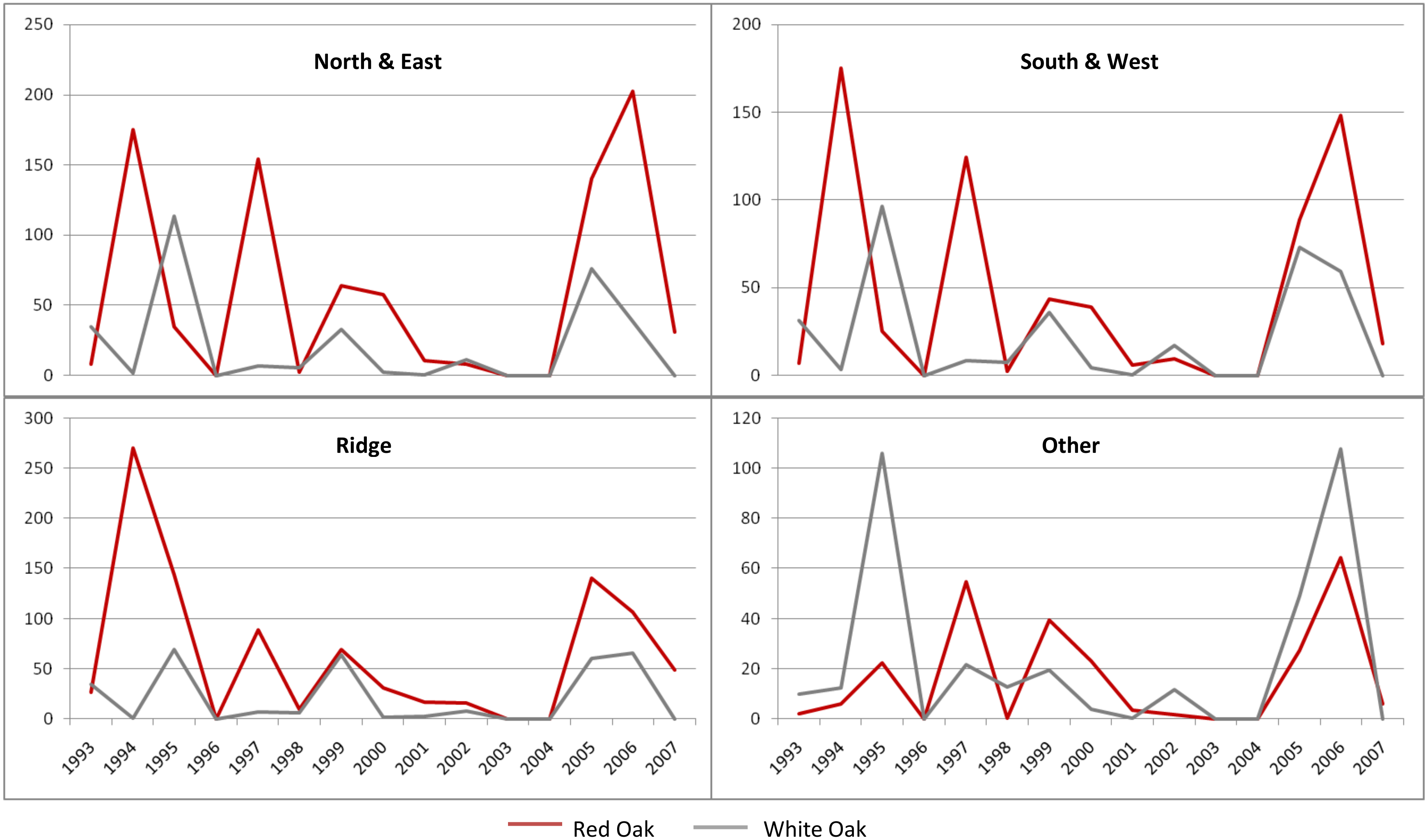
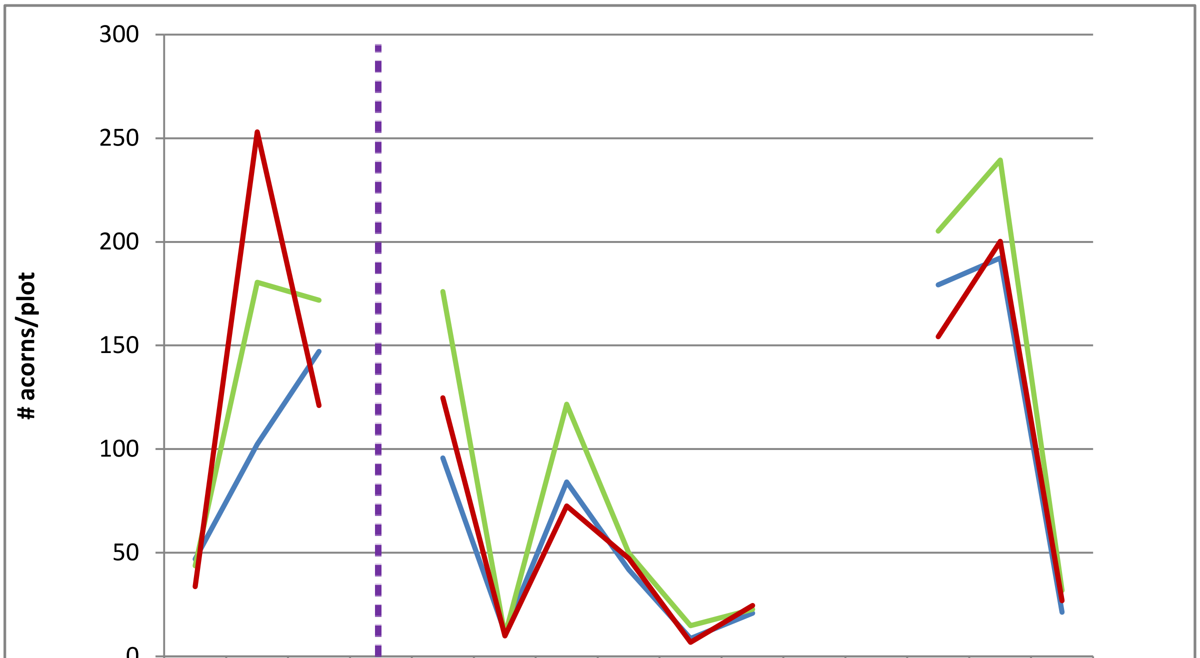


Figure 6. Average acorns per plot by ELT for each oak subgroup. Note: Y-axes are not all on the same scale. (n= NE 46, Other 12, Ridge 21, SW 51)



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
EAM	46.9	102	147		95.6	11.5	84.1	41.7	8.52	20.7			179	192	21.3
NM	43.7	180	172		176	10	122	49.9	14.8	22.6			205	239	31.8
UAM	33.7	253	121		125	9.84	72.6	47.2	6.81	24.5			154	200	26.9

Figure 7. Acorns per plot by forest management type. For Figs. 7 & 8 – n = EAM 44, UAM 43, NM 44. The purple dotted line indicates when the first harvest occurred.

Table 4. Acorns per plot by oak subgroup and forest treatment.

	Red			White		
	EAM	UAM	NM	EAM	UAM	NM
1993	6	10	15	41	23	29
1994	100	250	176	2	4	4
1995	33	45	66	115	77	105
1996						
1997	89	116	164	7	9	12
1998	3	2	5	8	8	5
1999	52	53	58	32	19	63
2000	38	44	47	4	3	2
2001	7	7	14	1	0	1
2002	5	12	11	16	12	11
2003						
2004						
2005	105	100	125	75	55	80
2006	132	155	172	61	45	67
2007	21	27	32	0	0	0

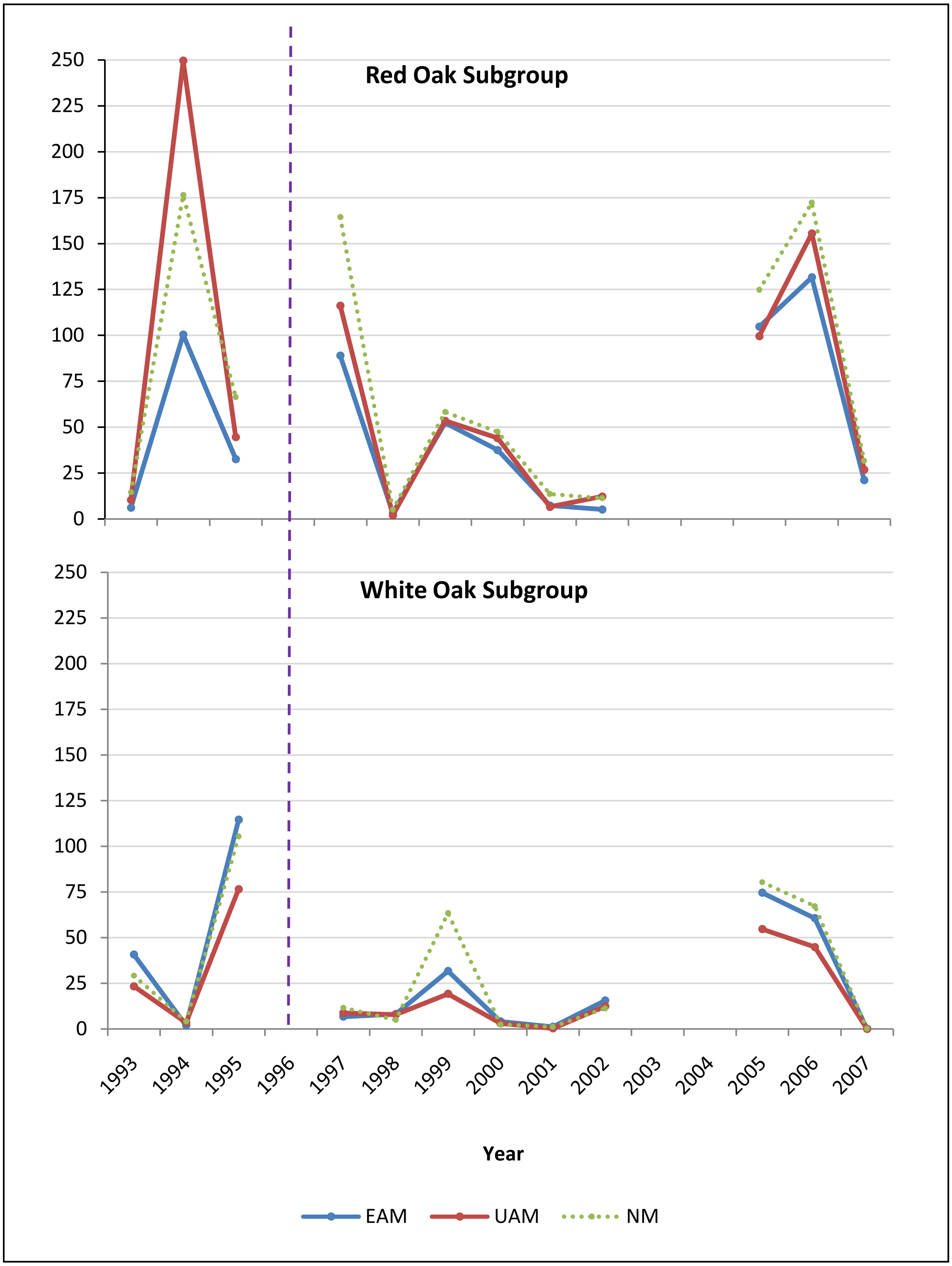


Figure 8. Acorns per plot by forest management type and oak subgroup.